Falling Natural Rates, Rising Housing Volatility and the Optimal Inflation Target

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Introduction

- Four unfavorable macro trends in advanced economies:

  (1) secular decline in growth rates (Summers (2014))

  (2) secular decline in natural interest rates (Holston et al. (2017))

  (3) upward trend in the volatility of housing prices (NEW)

  (4) upward trend in the *volatility* of natural rates (NEW)

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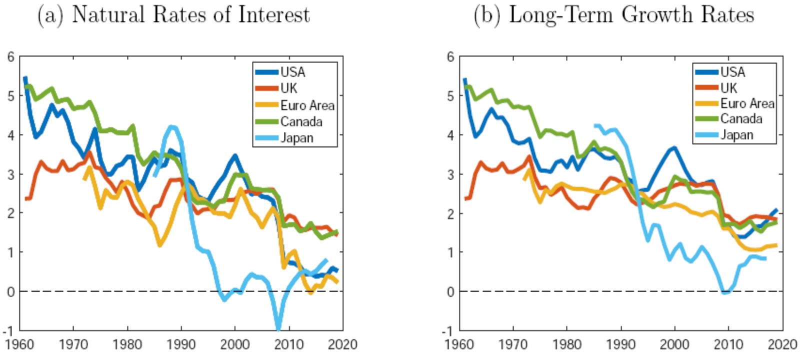
- Common cause linking all four macro trends?

- Monetary policy implications of these macro trends?

Known trends: lower growth & natural rates



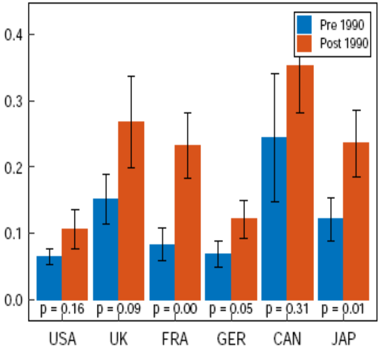
Source: Holston et al. (2017) and Fujiwara et al. (2016)

Rising housing volatility & natural rate volatility

- Macro volatility changes difficult to measure:
  - few observations
  - persistent variables, e.g., price-to-rent ratio

- Compare volatility changes over long time periods
  $\sim$1960-1990 versus 1990-2020

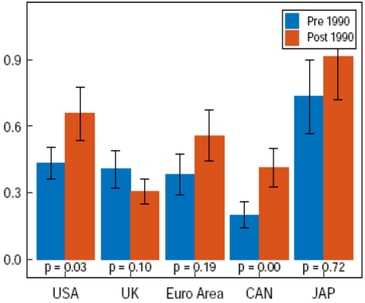
Rising Std. Deviation of the Price-to-Rent Ratio



Source: OECD database. The black lines denote the 90%-confidence bands. The p-values are for the null hypothesis the standard deviation has not changed pre to post 1990.

Rising Std. Deviation of the Natural Rate

Figure 2: Volatility of Natural Rates



Source: Holston et al. (2017) and Fujiwara et al. (2016) (natural rate estimates). The black lines denote the 90%-confidence bands. The reported p-values are for the null hypothesis that volatility has not changed from pre to post 1990.

Contributions of the paper

- Present a macro model linking these trends:

  - lower growth rates => lower average natural rates

  - lower natural rates => vola of housing prices & natural rates $\Uparrow$

  - complicates monetary stabilization: lower bound on nominal rates

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- Present a macro model linking these trends:

  - lower growth rates => lower average natural rates

  - lower natural rates => vola of housing prices & natural rates $\Uparrow$

  - complicates monetary stabilization: lower bound on nominal rates

- Determine

  - optimal MP with lower bound constraint on nominal rates

Main Findings

- Consider NK model with housing sector, lower bound, and subjective housing price beliefs (other beliefs rational)

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- Extrapolative behavior in asset price & other forecasts, e.g.,
  Adam, Marcet & Beutel (AER, 2017)
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- Housing forecasts from Michigan HH Survey:
  Subjective beliefs match forecast error structure

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- Housing forecasts from Michigan HH Survey:
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- RE hypothesis inconsistent with Michigan forecasts

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- NK model with subjective housing price beliefs:
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- More volatile housing price expectations
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  => interest rates restoring (objectively) optimal cons. more volatile

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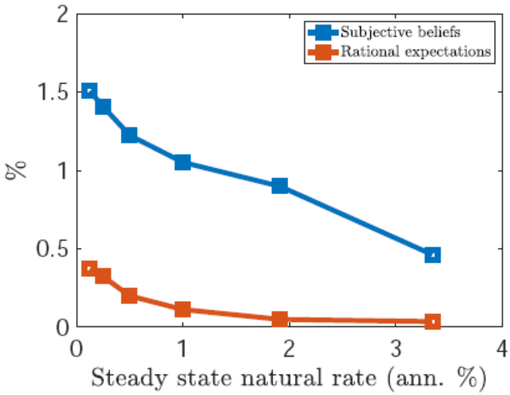
- More volatile housing price expectations
  => more volatile (subjective) plans for non-housing consumption
  => interest rates restoring (objectively) optimal cons. more volatile

- Rational housing expectations:
  No volatility increase in natural rates from lower av. natural rates

The Optimal Inflation Target



Structure of Presentation

1. NK model with housing & lower bound constraint
2. Optimal policy problem & economic mechanisms

NK Model with Housing

- Representative HH:

$$\max E_0^{\mathcal{P}} \sum_{t=0}^{\infty} \beta^t \left[\tilde{u}(C_t;\xi_t) - \int_0^1 \tilde{v}(H_t(j);\xi_t)dj + \tilde{\omega}(D_t + D_t^R;\xi_t) \right]$$

$$s.t.:$$

$$C_t + B_t + (D_t - (1-\delta)D_{t-1})\, q_t + k_t + R_t D_t^R =$$

$$\tilde{d}(k_t;\xi_t)q_t + \int_0^1 w_t(j)H_t(j)dj + \frac{B_{t-1}(1+i_{t-1})}{\Pi_t} + \frac{\Sigma_t + T_t}{P_t}$$

- $\mathcal{P}$: subjective housing price beliefs, otherwise rational beliefs

NK Model with Housing

- Model formulated in terms of growth-detrended variables
- Discount rate β jointly captures:

  - pure time preference rate $\widetilde{\beta} \in (0, 1)$

  - the steady-state growth rate g_c of marginal utility.

$$\beta \equiv \widetilde{\beta} \frac{\tilde{u}_C(C(1 + g_c))}{\tilde{u}_C(C)},$$

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$$\beta \equiv \widetilde{\beta} \frac{\tilde{u}_C(C(1+g_c))}{\tilde{u}_C(C)},$$

- Growth rate g_c falls $=>$ discount rate β increases
- Decline in growth & natural rate captured via increase in β

NK Model with Housing

- Internally rational households & firms (Adam&Marcet (JET, 2011))
- HHs choose $\left\{C_t, H_t(j), D_t, D_t^R, k_t, B_t\right\}_{t=0}^{\infty}$ to maximize utility subject to the budget constraints
- Beliefs about variables beyond their control given by $\mathcal{P}$: $\left\{P_t, w_t(j), q_t^u, R_t, i_t, \Sigma_t / P_t, T_t / P_t\right\}$, where

  $q_t^u \equiv q_t \tilde{u}_C(C; \xi_t)$ is housing price in marginal utility units

NK Model: Household Optimality Conditions

- Set of standard FOCs: labor-leisure choice, cons. Euler EQ

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- Set of standard FOCs: labor-leisure choice, cons. Euler EQ
- 3 new optimality conditions:

  Optimal housing demand : $q_t^u = \xi_t^d + \beta(1-\delta) E_t^{\mathcal{P}} q_{t+1}^u$

  Optimal housing investment: $k_t = \left(A_t^d q_t^u \frac{C_t^{\tilde{\sigma}-1}}{\bar{C}_t^{\tilde{\sigma}-1}} \right)^{\frac{1}{1-\tilde{\alpha}}}$

  Purchase vs. renting margin: $\xi_t^d = R_t \tilde{u}_C(C_t, \xi_t)$

NK Mode: Optimal Price Setting by Firms

- Supply side standard:

  - differentiated goods with Calvo price stickiness $\alpha \in (0, 1)$

  - Dixit-Stiglitz aggregation

- Standard firm FOCs for optimal reset price: Phillips curve

- New feature: wage/marginal costs depend on housing prices

Structure of Presentation

1. New Keynesian model with housing & lower bound constraint
2. **Optimal policy problem & economic mechanisms**

Nonlinear Optimal Policy Problem

$$\max_{\{Y_t, q_t^u, p_t^*, w_t(j), P_t, \Delta_t, i_t \geq 0\}} E_0 \sum_{t=0}^{\infty} \beta^t U(Y_t, \Delta_t, q_t^u; \xi_t)$$

$$\begin{aligned}
\left(\frac{p_t^*}{P_t}\right)^{1+\eta(\phi-1)} &= \frac{E_t^{\mathcal{P}} \sum_{T=t}^{\infty} (\alpha)^{T-t} Q_{t,T} \frac{\eta\phi w_T(j)}{\eta-1} \left(\frac{Y_T}{A_T}\right)^{\phi} \left(\frac{P_T}{P_t}\right)^{\eta\phi+1}}{E_t^{\mathcal{P}} \sum_{T=t}^{\infty} (\alpha)^{T-t} Q_{t,T}(1-\tau_T) Y_T \left(\frac{P_T}{P_t}\right)^{\eta}} \\
(P_t / P_{t-1})^{\eta-1} &= (1-(1-\alpha)(p_t^*/P_t)^{1-\eta})/\alpha \\
\Delta_t &= h(\Delta_{t-1}, P_t/P_{t-1}) \\
w_t(j) &= \lambda \frac{\bar{H}_t^{-\nu}}{\bar{C}_t^{\tilde{\sigma}^{-1}}} \left(\frac{Y_t}{A_t}\right)^{\phi\nu} C(Y_t, q_t^u, \xi_t)^{\tilde{\sigma}^{-1}} \left(\frac{p_t^*}{P_t}\right)^{-\eta\phi\nu} \\
\tilde{u}_C(C(Y_t, q_t^u, \xi_t); \xi_t) &= \lim_{T\to\infty} E_t^{\mathcal{P}} \left[\tilde{u}_C(C_T; \xi_T)\beta^T \prod_{k=0}^{T-t} \frac{1+i_{t+k}}{P_{t+k+1}/P_{t+k}}\right] \\
q_t^u &= \xi_t^d + \beta(1-\delta) E_t^{\mathcal{P}} q_{t+1}^u
\end{aligned}$$

Optimal Policy with Lower Bound Constraint

- Can derive insightful LQ approx. to nonlinear policy problem

- Helps understanding stabilization trade-offs for output & inflation

Optimal Policy with Lower Bound Constraint

$$\max_{\{\pi_t, y_t^{gap}, i_t \geq \underline{i}\}} -E_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{2} \left(\Lambda_\pi \pi_t^2 + \Lambda_y \left(y_t^{gap}\right)^2 + \Lambda_q \left(\widehat{q}_t^u - \widehat{q}_t^{u*}\right) \right)$$

$s.t.:$

$$\pi_t = \beta E_t \pi_{t+1} + \kappa_y y_t^{gap} + \kappa_q \left(\widehat{q}_t^u - \widehat{q}_t^{u*}\right) + u_t$$

$$y_t^{gap} = \lim_T E_t y_T^{gap} - \varphi E_t \sum_{k=0}^{\infty} \left(i_{t+k} - \pi_{t+1+k} - r_{t+k}^{n,RE} \right) - \frac{C_q}{C_Y} \left(\widehat{q}_t^u - \widehat{q}_t^{u*}\right)$$

+Equation(s) determining $\left(\widehat{q}_t^u - \widehat{q}_t^{u*}\right)$

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s.t. :

$$\pi_t = \beta E_t \pi_{t+1} + \kappa_y y_t^{gap} + \underbrace{\kappa_q}_{<0} \left(\widehat{q}_t^u - \widehat{q}_t^{u*}\right) + u_t$$

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Possibility for non-inflationary housing price booms.

Optimal Policy with Lower Bound Constraint

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Optimal Policy with Lower Bound Constraint

- Under RE, HP fluctuations efficient:

$$\widehat{q}_t^u = \widehat{q}_t^{u*}$$

- Under RE:

  Optimal policy problem same as in standard NK model (w/o housing) and ZLB

- Assumption of rational HP price expectations rejected by Michigan survey data...

Housing Prices and Subjective Beliefs

- Consider Michigan Survey on HP expectations (2007-2019)

- Coibion-Gorodnichenko (AER, 2015) regressions

$$HP_{t+4} - E_t^{\mathcal{P}}\left[HP_{t+4}\right] = \alpha_{CG} + \beta_{CG}\left(E_t^{\mathcal{P}}\left[HP_{t+4}\right] - E_{t-1}^{\mathcal{P}}\left[HP_{t+4}\right]\right) + \epsilon_t$$

With RE: $\beta_{CG} = 0$

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- Adam, Marcet & Beutel (AER, 2017) regressions

$$HP_{t+4} - E_t^{\mathcal{P}}\left[HP_{t+4}\right] = \alpha_{AMB} + \beta_{AMB} HP_t + \epsilon_t$$

  With RE: $\beta_{AMB} = 0$

Housing Prices and Subjective Beliefs

Table: Regression Results, Michigan Survey

	2007 - 2019	2010 - 2019
β_{CG}	2.14^{***}	1.54^{***}
	(0.540)	(0.509)
β_{AMB}	-0.36^{**}	-0.08
	(0.147)	(0.109)

Housing Prices and Subjective Beliefs

- Subjective perceptions on HP growth (Adam, Marcet & Nicolini (2016))

$$q_t^u / q_{t-1}^u = b_t + \varepsilon_t,$$

$\varepsilon_t \sim iiN(0, \sigma_\varepsilon^2)$ an unobserved transitory component

b_t is an unobserved persistent component given by

$$b_t = b_{t-1} + \nu_t,$$

with $\nu_t \sim iiN(0, \sigma_\nu^2)$

Housing Prices and Subjective Beliefs

- With conjugate normal prior about unobserved b_t
- Subjective capital gain expectations

$$E_t^{\mathcal{P}}\left(q_{t+1}^u / q_t^u\right) = \beta_t,$$

given by Kalman filter

$$\beta_t = \beta_{t-1} + \frac{1}{\alpha}\left(q_{t-1}^u / q_{t-2}^u - \beta_{t-1}\right)$$

$1/\alpha$: Kalman gain

Housing Prices and Subjective Beliefs

Table: Forecast errors: subj. belief model versus data

			steady-state natural rate			
	2007 - 19	2010 - 19	3.34%	1.91%	1%	0.25%
β_{CG}	2.14^{***}	1.54^{***}	0.74	1.24	1.85	2.31
	(0.540)	(0.509)				
β_{AMB}	-0.36^{**}	-0.08	-0.07	-0.08	-0.10	-0.15
	(0.147)	(0.109)				

Housing Prices and Subjective Beliefs

- Equilibrium housing price

$$
\begin{aligned}
q_t^u &= \xi_t^d + \beta(1-\delta)E_t^{\mathcal{P}} q_{t+1}^u = \xi_t^d + \beta(1-\delta)\beta_t q_t^u \\
\implies & \quad q_t^u = \frac{\xi_t^d}{1-\beta(1-\delta)\beta_t}
\end{aligned}
$$

- This equation & belief updating equation determine HP dynamics

Housing Prices and Subjective Beliefs

- Equilibrium housing price

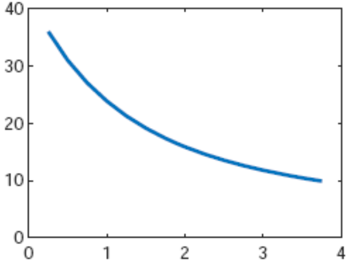
$$q_t^u = \xi_t^d + \beta(1-\delta)E_t^{\mathcal{P}} q_{t+1}^u = \xi_t^d + \beta(1-\delta)\beta_t q_t^u$$
$$\Longrightarrow \quad q_t^u = \frac{\xi_t^d}{1-\beta(1-\delta)\beta_t}$$

- This equation & belief updating equation determine HP dynamics
- Lower growth rates/natural rates (higher disc. factor β):

  Housing prices more sensitive to belief revisions β_t!

Housing Prices and Subjective Beliefs

Figure 5: Unconditional standard deviation of housing prices q_t^u



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Given $\{\widehat{q}_t^u - \widehat{q}_t^{u*}\}_{t=0}^{\infty}$

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Given $\{\widehat{q}_t^u - \widehat{q}_t^{u*}\}_{t=0}^{\infty}$

- Volatility of housing price gap => volatility of natural rate!

Optimal Policy with Lower Bound Constraint

- Natural rate: real rate consistent with stable output gap
- The natural rate under subjective beliefs:

$$r_t^n \equiv r_t^{n,RE} \underbrace{-\frac{1}{\varphi}\frac{C_q}{C_Y}}_{>0} \left(\left(\widehat{q}_t^u - \widehat{q}_t^{u*} \right) - E_t \left(\widehat{q}_{t+1}^u - \widehat{q}_{t+1}^{u*} \right) \right)$$

- More volatile housing prices (say due to lower average natural rate) => more volatile natural rate!

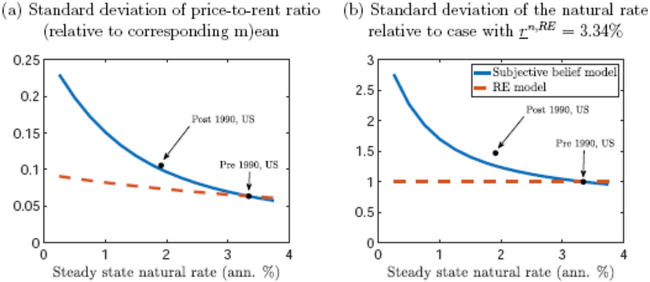
Model Calibration

- Calibrate the model to match the pre-1990
  (1) average natural rate
  (2) volatility of the natural rate
  (3) volatility of price-to-rent ratio
- Do this for the RE model and the Subj. Belief model
- What happens as natural rate falls to post-1990 average (or lower):
  - increase in the discount factor β
  - may reflect lower steady-state growth

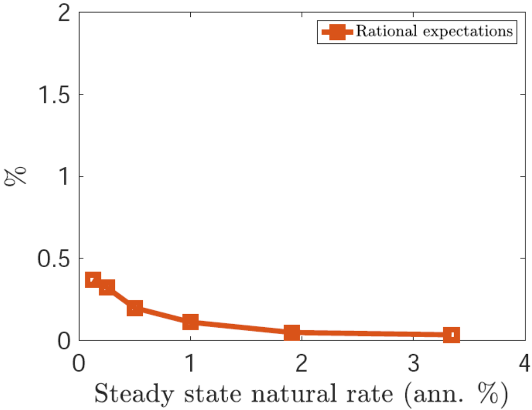
Model Calibration

Parameter	Value	Source/Target
		Preferences and technology
β	0.9917	Average U.S. natural rate pre 1990
φ	1	Adam and Billi (2006)
κ_y	0.057	Adam and Billi (2006)
$\frac{\Lambda_y}{\Lambda_\pi}$	0.007	Adam and Billi (2006)
κ_q	-0.0023	Adam and Woodford (2020)
$\frac{C_q}{C_Y}$	-0.29633	Adam and Woodford (2020)
s^d	15%	Adam and Woodford (2020)
δ	0.03/4	Adam and Woodford (2020)
		Exogenous shock processes
ρ_{r^n}	0.8	Adam and Billi (2006)
σ_{r^n}	0.2940% (RE)	Adam and Billi (2006)
	0.1394% (subj beliefs)	
ρ_{ξ^d}	0.99	Adam and Woodford (2020)
σ_{ξ^d}	0.0233 (RE)	Std. dev. of price-to-rent ratio pre 1990
	0.0165 (subj. beliefs)	
		Subjective belief parameters
α	1/0.007	Adam et al. (2016)
β^U	1.0031	Max percent deviation of PR-ratio from mean

Model: Non-targeted Moments



Average Inflation under Optimal Monetary Policy



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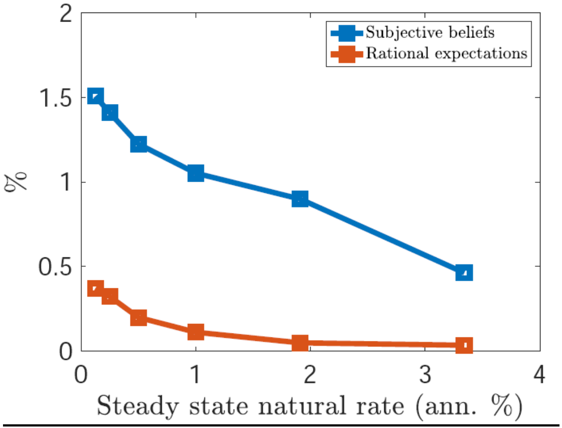

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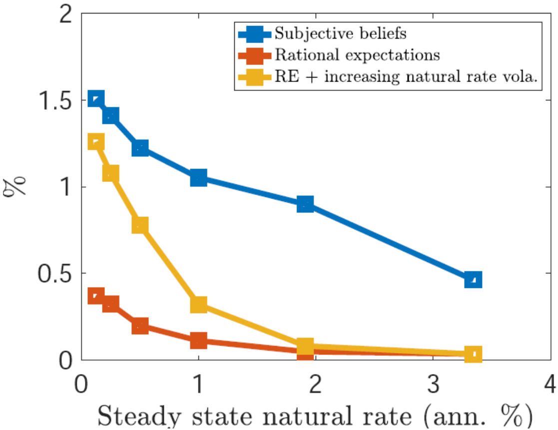


Conclusions

- NK model with subj. housing beliefs

  - consistent with survey evidence on housing expectations

  - lower natural rates: larger housing price & natural rate volatility

  - justify higher inflation targets due to ZLB constraint

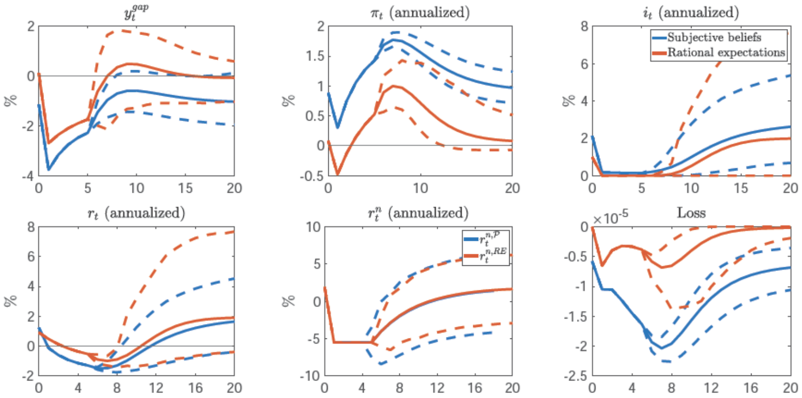
Conclusions

- NK model with subj. housing beliefs
  - consistent with survey evidence on housing expectations
  - lower natural rates: larger housing price & natural rate volatility
  - justify higher inflation targets due to ZLB constraint
- Reversing unfavorable macro trends: boost long-term growth trend

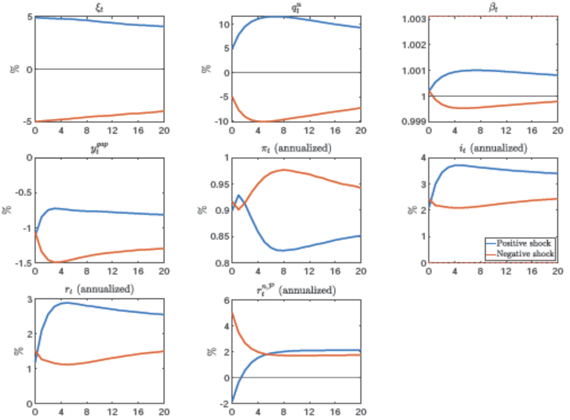
Impulse Repsonse Analysis for ZLB Event

- Start economy in period 0 at ergodic mean of state variables
- 6 quarters negative natural rate that puts RE economy to ZLB & no other shocks
- After quarter 6: all shocks move gain according to their stochastic laws of motion
- Show the mean response: average over all path
- Show the 1% and 99% percentile of the response distribution
- Put the same shocks into the subjective belief model

Impulse Repsonse Analysis for ZLB Event



(Asymmetric) Leaning Against Housing Demand Shocks



Std. Deviation of the Price-to-Rent Ratio

(a) Standard Deviation of the Price-to-Rent Ratios for Different Sample Splits.